DEPARTMENT OF THE NAVY
NAVAL INDUSTRIAL RESOURCES
SUPPORT ACTIVITY
PHILADELPHIA, PA

BEST MANUFACTURING PRACTICES

REPORT OF SURVEY CONDUCTED AT

HARRIS CORPORATION GOVERNMENT SUPPORT SYSTEMS DIVISION SYOSSET, NY

SEPTEMBER 1986

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The purpose of the Best Manufacturing Practices (BMP) survey conducted at this facility was to identify their best practices, review manufacturing problems, and document the results. The intent is to extend the use of progressive management techniques as well as high technology equipment and processes throughout the U.S. industrial base. The actual exchange of detailed data will be between contractors at their discretion. A company point of contact is listed in the report

The intent of the BMP program is to use this documentation as the initial step in a voluntary technology sharing process among the industry.

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I. INTRODUCTION

A. Scope

The purpose of the Best Manufacturing Practices (BMP) Review conducted at Harris Corporation was to identify best practices, review manufacturing problems and document the results. The intent is to extend the use of high technology equipment and processes throughout industry. The ultimate goal is to strengthen the U.S. industrial base, solve manufacturing problems, improve quality and reliability, and reduce the cost of defense systems.

To accomplish this, a team of Navy engineers reviewed Harris' Government Support Systems Division (GSSD) to identify the most advanced manufacturing processes and techniques used in that facility. Manufacturing problems that had the potential of being industry wide problems were also reviewed and documented for further investigation in future BMP reviews. Demonstrated industry wide problems will be submitted to the Navy's Electronics Manufacturing Productivity Facility for investigation of alternatives to resolve the problems.

The review was conducted at Harris GSSD in Syosset, New York on 9-12 September 1986 by the team of Navy personnel identified on page 2 of this report. Harris is primarily engaged in advanced research, development and production of automatic test and maintenance systems for the check-out of electronic equipment and avionic modules on military aircraft.

Based on the results of BMP reviews, a baseline is being established from which a data base will be developed to track best practices and manufacturing problems. The information gathered will be available for dissemination through an easily accessible central computer. The actual exchange of detailed data will be between contractors at their discretion.

The results of this review should not be used to rate Harris GSSD among other defense electronics contractors. A contractor's willingness to participate in the BMP program and the results of a survey have no bearing on one contractor's performance over another's. The documentation in this report and other BMP reports is not intended to be all inclusive of a contractor's best practices or problems. Only selected non-proprietary practices are reviewed and documented by the BMP survey team.

B. Review Process

This review was performed under the general survey plan guidelines established by The Department of the Navy. The review concentrated on three major functional areas: management, design engineering and manufacturing. Harris identified potential best practices and potential industry wide problems. These practices and problems, and other areas of interest identified were discussed, reviewed and documented for dissemination throughout the U.S. industrial base.

C. BMP REVIEW TEAM

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II. SUMMARY

The Best Manufacturing Practices Survey Team evaluated management, design and manufacturing functions. Areas reviewed included Harris' management policies and strategy, transition planning, design and production engineering, computer aided design, material procurement, receiving inspection, facilities, integrated testing, quality assurance, material handling, inventory control, computer aided manufacturing and vendor selection and control. The team also discussed manufacturing problems such as component solderability, vendor quality control, part marking, and WS 6536.

The format for this survey consisted of formal briefings and discussions on best practices and problems. Time was spent on the factory floor reviewing practices, processes and equipment. In-depth discussions were conducted with GSSD personnel to document, in detail, some of the practices and problems identified.

Harris GSSD is in the process of setting up their factory of the future or paperless factory. They have an overall strategy plan for accomplishing this goal. Many management, design, quality, test, and manufacturing functions have already been automated and integrated into the overall scheme. Areas that didn't justify full automation have been semi-automated where feasible. The most impressive element of this entire effort is the cohesiveness of management and the workforce. New ideas and technologies are being adapted and implemented with little or no resistance, allowing the effort to progress smoothly.

Harris uses a team approach within the management organization. There is good flow of information between the different departments. All departments are involved in problem solving, new program development, and quality and productivity improvements. There is a total approach to the management and operation of Harris GSSD. Program managers are delegated complete control of their programs with program director reviews conducted monthly for the general manager, his staff, and the vice presidents. This practice fosters excellent staff communications.

Design Engineering receives a significant amount of attention at Harris. Guidelines have been developed to control the design process and selection of parts and materials. Deviation from the use of standard parts requires approval from the directors of hardware design, manufacturing, and manufacturing engineering. Circuit designs and both analog and digital simulations are performed on Daisy computer aided engineering workstations. The Daisy workstations are linked to an IBM mainframe to make design data available for physical design computer aided manufacturing and other program support functions. The computer aided physical design software package is used to layout the tooling holes and routing of the PCB being designed. Mechanical design, integrated with the electrical

design, is also done on the mainframe via local graphics terminals. Files are generated from the software and passed to the subcontractor who manufacturers the boards for Harris.

Harris has developed a manufacturing operating system that integrates various modules to control and monitor manufacturing flow operations. Material movement and real time updating of work-in-process is monitored by this system. Computer integrated manufacturing plays a major role in Harris' factory of the future. Many of the manufacturing operations are fully automated while others are semi-automated. Automatic prepping, insertion, assembly, and test equipment is utilized where the application is practical. Bar coding and defect analysis are used extensively to track and control manufacturing.

The manufacturing problems identified and discussed were not unique. Component solderability, vendor quality control, non-standard part marking, part marking permanency, and WS 6536 compliance have been discussed at most of the other facilities surveyed by the BMP team.

The best manufacturing practices and problems identified at GSSD will be evaluated and reviewed by the Navy team during future BMP surveys. Those practices identified as being among the best in the electronics industry will be documented in a central data base for dissemination throughout the industrial base. The industry wide problems will be investigated by the Navy in an effort to develop alternatives for their resolution.

III. BEST PRACTICES

The practices listed in this section are those identified by the Navy BMP survey team as having the potential of being among the best in the electronics industry. This judgment is based on experience from previous BMP surveys and expertise gained by team members through years of working relationships with industry.

A. Management

ANNUAL OPERATING PLAN

Harris Corporation operates with an "Annual Operating Plan" as its standard or guideline. This Annual Operating Plan is the result of much planning at the Director through corporate level. Harris operates on the "Management by Objectives" philosophy. Objectives are established, approved at corporate level, and then included as part of a one year plan (Annual Operating Plan).

The basis of the plan consists of the objectives agreed upon for each Director at a meeting attended by that Director, his Vice President, and other Directors.

This meeting is conducted annually and off-site. The off-site location is chosen to avoid interruptions that would routinely occur if held at the plant location. At the conclusion of the meeting, each Director knows not only his own agreed upon objectives but also those of the other Directors within his division as well. This results in a team concept among Directors and each is expected to cooperate with the other(s) to assist in meeting these objectives.

TEAM MANAGEMENT APPROACH

Harris has an excellent working relationship between the organizational departments. Management, Manufacturing, Engineering, and Quality Assurance communicate with one another and depend on each other's experience/expertise to resolve problems, develop new programs, and improve quality and productivity. Meetings and reviews are held frequently to discuss both the positive and negative aspects of operations. Long range plans for GSSD are developed with input from and negotiations with all departments. This method has helped Harris GSSD to compile a central plan to modernize and improve the division with equal input from each department.

The team effort approach used at Harris has proven to be beneficial. There is a total approach used by the division instead of each department operating on its own in isolation of the overall division goals and objectives.

CAPITAL INVESTMENT COMMITMENT

Harris has shown continued growth in the amount of capital investment since FY-82, with the amount planned in FY-87 being three times the amount committed in FY-82. Commitments have been made to modernization and automation of processes. The modernization/automation is not being implemented blindly, but it is a highly coordinated effort that is well thought out and suited to the Harris operation. Processes may not be fully automated, but may be semi-automated based on production quantities. This modernization effort has reduced operator errors and cost and has improved throughput.

AUTOMATED COST ESTIMATING

Automated Cost Estimating (ACE) is an automated cost estimating system developed by Harris to enhance the cost proposal cycle. It is based on the Symphony spreadsheet package and draws upon various databases in the MIS system to extract pertinent data for product structure, labor and overhead standards, and component pricing. The information is down-loaded

to a very user friendly PC environment where a variety of cost and pricing estimates can be developed.

The system improves the efficiency, accuracy and consistency of the estimating process. ACE, like any spreadsheet, allows Harris to perform a variety of detailed analyses including "what if" scenarios in a very short time.

EXECUTIVE WORKSTATION

The Executive Workstation was developed to provide Vice Presidents and Directors a computer-based information system to improve their access to company data which already exists in electronic and/or paper form. The distributed application is micro-based with workstations at the Manufacturing Vice-President as well as the Manufacturing Director level. All workstations are linked to an IBM 4381 system which enables access to data input by manufacturing, administration, assembly and test, and procurement. These workstations are able to run mainframe applications relating to performance indicators as well as micro based application software.

Performance information is available in both report and graphic format. Actual versus standard performance indicators can be accessed and grouped from a facility down to the employee level. The system can be expanded to allow manager level access. The Executive Workstation enables management to make smarter decisions and react in a more timely manner to competitive business conditions.

PROGRAM MANAGER AUTHORITY

Harris Corporation GSSD operates on the corporate philosophy that the Program Manager has complete control of his program. This includes all facets of the program; i.e., proposals, design, quality, schedule, cost, and customer liaison. Like the military officer, the Program Manager is responsible for all that his program does, or fails to do. To do this, Harris uses the "overlay" management philosophy which allows the Program Manager to use elements of the "vertical" organizational elements that are required by his program; i.e., manufacturing, engineering, marketing, etc. As a result of this corporate philosophy, program responsibility does not resemble an "asterisk"; instead, it resembles a "period" - one person/manager. This is a good practice because it simplifies and localizes program responsibility.

The corporation/division operates more economically under this concept because only one set of organizational functions is required. The alternative to this is that each program has its own "mini-set" of dedicated organizational functions. This "traditional" concept results in a complicated, uneconomical management structure.

PROGRAM DIRECTOR REVIEWS

The Program Director Review is conducted monthly for the General Manager, his staff, and the GSSD Vice-Presidents. At this meeting, the Program Directors present formal reviews of the status of each program for which that Director is responsible.

Individual Program Managers are on-call to assist the Program Directors as required. This meeting (review) is another means by which Harris maintains its staff communications. As a result of this monthly review, the General Manager is able to make informed program decisions and recommendations.

INSPECTION PRODUCTIVITY

A great deal of effort has been directed toward making productivity improvements in the area of manufacturing. This is a common practice in industry. Harris GSSD is doing something unique in productivity, applying it to quality assurance in the area of inspection. Delivering a quality product to the customer is not good enough. Quality Assurance has launched an effort to reduce the throughput time for inspections. Test equipment, methods, defects, and rework are being studied to identify ways to reduce cycle time and cost while improving productivity. An example of this, using a piece of otherwise obsolete manufacturing equipment to perform an inspection operation, is discussed on page 16 of this report.

DEFECT CONTROL

The Defect Analysis System being used by Harris gives defect data to management in a usable format in a timely manner. The data is inputted via bar code readers so that the data is available on an immediate basis. The format of the data is presented in graphic form so that it is easily readable and it can be presented in different formats sorted by board type, type of defect, etc. There is a concentrated effort to insure that the data is up to date and that it is presented in a form that can and will be used. Planned is a board that will present improvements in defect rates and problem areas to the employees with a method to recommend changes to solve problems.

SUPPLIER CONTROL

Harris GSSD has embarked on a Supplier Control Program, the objective of which is to obtain a zero defects level of quality from its suppliers. In this program, the suppliers are vigorously impressed with the importance of their compliance to the concept. The suppliers, in turn, realize that the same standards must be imposed on their suppliers, etc. The Quality Assurance Department is in charge of the program with the total

cooperation of the Procurement Department. This Supplier Control Program will prove to be extremely beneficial to GSSD and the Government.

COMMUNICATION

Communication at and between all levels at GSSD is probably the best observed by the BMP survey team. There appears to be a positive attitude throughout the division at all levels.

An All Employee Meeting is held annually to report on the performance of GSSD for the past year and to advise employees of future prospects for GSSD. To keep all personnel informed and to communicate with them are elements of good management. These are practices that poorly managed companies fail to use and otherwise well managed companies many times overlook.

EMPLOYEE ATTITUDE SURVEY

Harris conducts a survey on a regular basis (approximately 18 month intervals) to assess employee attitudes regarding the company, their jobs, working conditions, etc.

The survey is conducted by an independent firm. Approximately 50 questions are asked of each employee. The confidential answers are analyzed by the contractor and reported back to Harris. The data provided to Harris is for the division as a whole, as well as for directorates and individual departments. After Harris receives the data, additional feedback sessions are arranged with the employee groups. During these sessions, additional comments are sought out to augment the statistical data.

The management at Harris GSSD feels that the surveys are a useful tool that helps them to analyze employee perceptions and take corrective action when necessary and feasible.

PEOPLE PROGRAM

The People Program in-place at Harris GSSD is very similar to employee involvement programs such as "Quality Circles" observed at other companies. The People Program differs from others observed in that management is more directly involved. The program consists of a Steering Committee, Employee Involvement Teams (EIT's) and System Improvement Projects (SIP's).

The Steering Committee is comprised of the General Manager and his staff. EIT's are work groups of employees organized to identify and solve problems in their immediate work area(s). SIP's teams execute management directed projects that address system oriented problems. GSSD is in its first year of the program and already feels that it is worthwhile. GSSD esti-

mates the dollar return of the People Program is seven to one. The program was allocated $130,000 for its first year budget and has been so successful that GSSD has budgeted $300,000 for its second year. Although this program is not entirely unique, it has had a significant, positive effect at Harris GSSD.

B. Design

DESIGN GUIDELINES

Design guidelines for PWB assembly including single-sided, double-sided, multi-layered, and multi-wired designs have been incorporated into Harris' design policy. The purpose of these guidelines is to reduce costs and improve the quality of PWB assemblies by establishing a set of design parameters which outline manufacturing concerns for producibility. It is intended that this procedure will act as a single, common source of information which engineering can design to and manufacturing can review against. The PWB guidelines are to be considered alongside many other system and functional requirements.

The PWB design guidelines have a "consideration for producibility" section which is divided into two groups: absolutes and goals. The "absolutes" are design parameters (guidelines) which have been programmed directly into the CAD system. There should be no deviation from these parameters without approval from the Directors of Hardware Design, Manufacturing, and *Manufacturing Engineering*. The "goals" portion of the producibility section consists of goals that the Design Engineer should strive to adhere to when designing a PC board. The results of meeting these absolutes and goals will be a better manufactured PC board at lower cost.

DESIGN ANALYSIS

Harris uses a series of Daisy CAE workstations linked together using ETHERNET to design all of its circuits. Use of the Daisy system allows Harris not only to design circuits but also to perform both analog and digital simulations of these circuits using a support software package for the Daisy and IBM-AT based Daisy systems. Capabilities such as analog and digital simulation enable the detection of circuit defects prior to the analysis performed by prototyping. Use of these functions enabled Harris Engineering to produce an electrical functionability and performance defect-free prototype on several occasions.

PARTS AND MATERIALS SELECTION

To ensure the uniform application of parts and materials by all design engineers, Harris controls use of standard components by maintaining a standard component file which is integrated with the computer aided engineering functions. When an engineer designs a circuit, component selection is limited to those components available in the standard component file, accessible only through a menu. This standard component file was created and is maintained by a separate Design Standard Department. Incorporation of any components not found on the standard component file involves obtaining approval and qualification by standards engineering.

COMPUTER AIDED DESIGN

Harris has established a common database to integrate Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) operations. This has resulted in significant cost, schedule, quality, supportability, and performance benefits. The software selected for this database management system is FOCUS, which resides on the IBM 4381 computer.

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COMPUTER AIDED DESIGN FLOW-DOWN

Upon circuit design completion, Harris uses an IBM 4381 based CAD software package called Circuit Board Design System (CBDS) to layout the tooling hole and routing of the PCB being designed. Once completed, Harris uses a CBDS utility called FABRIC to generate GERBER files containing the necessary silk-screen and drill tape data to be used in the manufacturing of the circuit board with its respective layers. These GERBER files are then given to the subcontractor who manufactures the boards for Harris. The use of CAD flow-down technology is a significant factor in reducing the risk in transitioning from development to production.

ENGINEERING PERSONNEL EXCHANGE

Harris has performed a one-time exchange of Manufacturing Engineering personnel and Design Engineering personnel. This one-time exchange involved sending one member of each group to the other group for a period of three months. The main objective of this exchange was for these persons to perform the duties of their counterparts in an effort to better understand the needs and concerns of the other's department as well as gain an understanding of the integration necessary. Feedback obtained from this exchange of personnel assisted in establishing the baseline for the PWB Design Guidelines. Harris was pleased with the results of this exchange and intends to continue this practice periodically.

C. Manufacturing

MANUFACTURING OPERATING SYSTEM

The Manufacturing Operating System integrates various modules to control and monitor manufacturing flow operations. The system consists of a single database with on-line transaction and database updating.

Capabilities include order processing, material requirements planning, inventory control, purchasing/receiving, shop floor control, and management exception reports. The inventory module can process inventories by separate contracts or co-mingled lots with transfer and loan payback between contracts. The production tracking portion enables monitoring of material movement and real time updating of work-in-process. The shop floor control consists of order tracking through the various work centers with on-line routing visibility. Data capture for these modules is accomplished through the extensive use of bar coding.

COMPUTER AUTOMATED MANUFACTURING METHOD SHEETS

The Computer Automated Manufacturing Method Sheets (CAMMS) System was developed by Harris to automate the tedious process of preparing manufacturing method sheets.

CAMMS utilizes the AUTOCAD software package in conjunction with a PC-AT and a high resolution color monitor. Method sheets appear on the screen, and the process planner can supply basic information in a very efficient manner. The AUTOCAD library enables Harris to reproduce tooling and component drawings very easily.

Harris states that CAMMS has demonstrated a 35% reduction in method sheet preparation time as well as a 60% reduction in update time. It is directly tied to the CAD database through an IGES translator. It also provides a real time link to the Harris GSSD manufacturing facilities, both in New York and Florida.

Harris intends to utilize artificial intelligence (AI) to further enhance the capabilities of the system and also intends to utilize the Univation support software to generate labor estimates at the same time that the method sheets are created.

COMPUTER INTEGRATED MANUFACTURING

The Harris GSSD Computer Integrated Manufacturing (CIM) Program is managed by a CIM Steering Group which consists of the Directors of Manufacturing Engineering, Hardware Engineering, and Management Information Systems (MIS).

This approach appears to be very effective in producing a coordinated effort. Harris seems to avoid many of the jurisdictional disputes encountered by other firms which have embarked on a comprehensive CIM program.

INTEGRATED TEST

The Integration and Test Organization at Harris GSSD is located within the Manufacturing Organization. The primary functions of the Integration and Test Organization include designing test equipment and test program sets for testing automatic test systems. The test organization also has responsibility for conducting the tests, as well as performing repairs of circuit boards, assemblies, and systems that failed test. It also supports field depots through updating production test sets, training depot personnel, and providing feedback.

Harris Corporation factory test equipment reflects a combination of manual, semi-automated, and automated test equipment, with plans to become more automated through procurement of additional capital equipment in the future.

The testing organization also seeks to improve testing capacity by training its operators to be more flexible by having the ability to operate a variety of test equipment.

The test organization has adopted the policy that, at a minimum, all modes of operation used by the printed circuit board in system operation will be tested. When a system level failure occurs, it is an ongoing practice to retest the board and review the test procedure to ensure that the failure mode is tested during board test.

AUTOMATED TEST EQUIPMENT CALIBRATION

Harris GSSD has a lot of test equipment requiring annual calibration. Processing this equipment through the standards lab required many man-hours of labor. The manual method to calibrate approximately 220 meters required 3568 manhours. Through the utilization of a Fluke A123 meter calibration system, calibration of the same number of meters now only requires 892 hours. A meter that once took a day and a half to calibrate can now be calibrated in two hours. A Fluke 7410A oscilloscope calibration system has also been purchased resulting in a 65% productivity increase. The Fluke 7410A system is fully automated and can verify and accurately calibrate oscilloscopes of any manufacturer. It is easy to operate and does not require a highly trained technician.

An HP8902S Signal Generator Calibrator was also purchased to facilitate calibration. This calibrator should result in a 75% savings in annual manhours. A Weinschel System II RF Power Measurement and Wiltron 560 Scaler Analyzer are being procured to calibrate power sensors, thermistor mounts, attenuators, isolators, and directional couplers in half the currently required time.

COMPUTERIZED WORK PERFORMANCE MEASUREMENT

Harris Corporation is in the development stage of implementing a computerized work performance measurement system. The system is based on the application of Univation Work Performance Measurement Software.

This system will calculate times derived from Motion Time Measurement (MTM) but does not require that level of detail work content to be supplied by the operator. For times to be derived the first time, mini-sets must be inputted by the industrial engineer. Once the mini-sets are established, the times of operation can be readily calculated by the system. The system is user friendly. The mini-sets become part of the Univation database. The system allows for mass updating through single changes to a mini-set, as processes or conditions dictate.

Future application of computerized work measurement will be in the generation of "performance indicators" for each operation, work cell, and operator. The mini-sets are currently used for generating the process work flow sheet that controls the movement of items through the fabrication cycle.

Eventually, as computerized work measurement is realized as an accurate tool, it will be applied to the function of cost estimating, cost review, and capital equipment cost analysis.

JUST-IN-TIME PURCHASING

An attempt to purchase commodities on a Just-In-Time (JIT) basis has been initiated by Harris. They have recently issued a contract to one vendor who is committed to supply wire to Harris on a JIT basis. The contract requires the vendor to stock 25% of Harris' annual requirements at any one time and to ship the wire to Harris within 24 hours.

As a result of this program, Harris will be able to significantly reduce its storeroom requirements as well as its inventory carrying costs. The vendor is also happy with the arrangement because he has a guaranteed contract for the total annual wire requirements. However, Harris is not liable if it loses a contract and does not produce the forecasted buy.

BAR CODING

Bar coding as a means of data capture for an integrated computer system is being applied at Harris GSSD. Areas of application are non-production test equipment and fixtures, dock-to-stock, production tracking, and timekeeping. The test equipment and fixtures system includes status. The dock-to-stock system enables tracking from arrival at the receiving dock through incoming inspection to the stockroom. The production tracking system enables monitoring of all work in process and movement between various work centers. Employee identification badges incorporate bar coding, thus allowing security and expansion to a timekeeping system and possible bypassing of keyboard input at terminals.

AUTOMATED PRE-TINNING OF COMPONENTS

Harris 100% pre-tins all components when the components are pulled from stock to be kitted. Axial and radial lead components are pre-tinned using an Electrovert Auto Arda, which is a semi-automated microprocessor controlled system. The system provides stringent process controls by accurately controlling the dip depth, dwell time, and dipping speed. The pre-tinned components have one-fifth the number of defects compared to kits not tinned.

Harris also pre-tins all non-socketed integrated circuits on a conventional wave-flow soldering machine with special fixturing built by Soldering Technology Labs. The special fixturing has a tilt table with a wave soldering fixture that allows tubes of DIP's to be placed on the table in the fixture. When the table is tilted the DIP's slide into the fixture. The fixture is then put through the wave soldering machine. The fixture is then put back on the tilt table with the original DIP tubes and tilted, so the DIP's slide back into their respective tubes in the same orientation as they were initially. This insures that the DIP's do not get in the tubes in the wrong orientation due to operator error. This process

allows the pre-tinning operation to be controlled more closely with less chance of human error or variability.

AUTOMATIC LEAD STRAIGHTENER

An American Technical Manufacturing AT-300 DIP Lead Straightener is being utilized to straighten DIP leads before they go into the DIP auto insertion machine. The machine takes tubes of DIP's and runs the DIP's through the straightening process back into a DIP tube on the other side. This process minimizes problems with bent leads which cause components not to insert.

AUTOMATED COMPONENT INSERTION

An Amistar 1000 system is being utilized to insert DIP components. Plans are under way to procure an upgraded system which will give the capability to insert more styles of DIP components as well as to perform tests on the parts to screen for faulty parts.

CS 400B's made by Contact Systems are being used to insert radial and axial lead parts. The machines can take data from the CAD/CAE database. The proper part is presented for the operator to install at the location and in the orientation designated by an indicator light. Once the part is inserted, the machine cuts and clenches the leads for better part retention. This system has resulted in an annual savings of $265K by improving productivity and reducing rework and reinspection since the operators make fewer errors using this system.

MICROPROCESSOR CONTROLLED WAVE SOLDERING

The wave soldering equipment now being utilized is an Electrovert Century 2000 system that has microprocessor controlled settings for speed, flux specific gravity, wave height, solder temperature, and board preheat temperature. These settings are monitored continuously. The readings are logged on the computer by each board run so that if any problems are noted later, the parameters can be verified at the time the board was run. The operator inputs a code for the type board and loads and unloads the conveyor. This eliminates operator variables during the process.

AUTO-ARM CLEANING PROCESS

The cleaning process has been semi-automated by using the auto-arm. The auto-arm controls the cleaning time, withdrawal time, hold time, and which cycles are performed as well as the number of cycles. This insures that the vapors condense before the basket is raised, saving on the amount of fluids used and

keeping it out of the air in the area as well as lessening operator exposure. It also insures that all boards get the proper amount of cleaning and the correct number of cleaning cycles. This automation has been done in all areas where cleaning is performed. The cost of this system is one-tenth the cost of an in-line cleaning system and for the volume being processed, the system works just as well as the in-line cleaning system.

FIRST PIECE INSPECTION

The first piece inspection of printed wiring boards for part location and identification is being done with the assistance of the semi-automatic Ragen parts locator on densely populated assemblies or where the reference designations are not in logical order. Program tapes are now available for six board types with five more being prepared. The operator follows the parts list with the Ragen equipment pointing out the next component to be inspected by a light dot. The Ragen equipment had been obsoleted from manufacturing by the discontinuance of large numbers of jumper wires on some board types. The equipment was then put to use in the inspection area. This provided good utilization of available resources and reduced inspection time by one-third.

IV. PROBLEM AREAS

The problems discussed below were identified by Harris GSSD as having the potential of being industry wide problems. The BMP survey team will collect more data on these problems from other contractors and government agencies. This data will be reviewed and those manufacturing problems considered to have an industry wide impact will be forwarded to the Electronic Manufacturing Productivity Facility, China Lake, California for research and resolution. Some of the problem areas may lead to the establishment of a government/industry ad hoc group to evaluate the concern and propose alternative solutions.

COMPONENT SOLDERABILITY

This is the fifth Best Manufacturing Practice Survey conducted by the Navy and the fifth time component solderability has been mentioned as a major problem. A number of individual contractor efforts have been initiated in an attempt to resolve this problem at the vendor/supplier level. Limited success has been achieved, but usually only for a short period of time. Most primes have reverted to pre-tinning component leads prior to assembly.

This problem will be discussed at the industry/Navy workshop in May 1987. The objective will be to establish a plan of action and milestones to fully document the magnitude of the problem and develop an approach to solve the problem.

VENDOR QUALITY CONTROL

Quality control at the supplier level was discussed at Harris as a problem. Steps have been taken to resolve the problem by establishing a Supplier Control Program which is discussed on page 7 of this report. Lessons can be learned from Harris' and other contractors' efforts documented in previous and future BMP reports and applied to maintain better quality control at the vendor level.

NON-STANDARD PART MARKING

The lack of standard electronic part marking has been identified by Harris and other companies as a problem. Different vendors and sometimes the same vendor supply the same part marked differently. This confuses inspectors and creates problems for computer vision inspection systems. A recommendation discussed was to require all suppliers to use a uniform marking standard. This would help reduce inspector errors and vision inspection system errors.

PART MARKING PERMANENCY

Today's sophisticated electronic systems require repeated cleaning during the assembly process. This cleaning process often eradicates the part marking required by military standards. A number of techniques have been employed in an attempt to make the markings more permanent. Some contractors have tried applying a coating over the marking while others have reduced the strength of the cleaning solutions. These attempts to solve the problem have not been completely successful. A few primes have been working with their suppliers in an attempt to get them to use a more permanent ink for marking. Although not required by military standards, this appears to be an answer to the problem if the vendors are willing to comply with the primes' requirement.

COMPLIANCE WITH WS-6536

Although Harris GSSD has made necessary investments and is committed to meeting required specifications, they have some reservations about the implementation of WS-6536. They acknowledge that WS-6536 can have a beneficial effect on the reliability of weapon systems. However, they question its applicability to support equipment, such as test systems which are typically operated in benign environments and where a circuit card can easily be replaced if it is bad. They also feel that it needs to be applied at the inception of a program rather than being introduced to an existing program; i.e., system design must accomodate the specifiction.

Harris argues that invoking of WS-6536 on their product line results in extensive additional costs to the customer, and benefits, if any, may not be in line with the cost. They state that it seems inconsistent to exempt subcontracted/commerical parts from the weapons specification. This results in some parts of the system meeting WS-6536 while other (commercial) components of the same system are not required to meet the specification.

Harris also pointed out that the waiting list at the Naval Weapons Center soldering school is up to eight months. Selective enforcement of WS-6536 would result in a shorter waiting list and would assure proper certification to those contractors that really need it.

V. CONCLUSIONS

The Navy has conducted six Best Manufacturing Practice Surveys in the past year. Of those conducted and the companies visited, Harris appears to be successful in implementing a program to achieve a modern factory that employs most of the best practices currently being used in the electronics industry. Management, engineering, quality, and manufacturing are working together to achieve the overall goal of reducing defects and cost while improving quality, productivity, and delivery.

Many of the management practices documented in this report are considered to be among the best in the industry. Harris' commitment to capital investments and movement toward computerization of management data enables them to make informed decisions in a very competitive environment. Real time access to program status, defects, cost, and schedule provide the tools necessary to take corrective action before a problem becomes critical. Harris GSSD also makes good use of their employees ideas and concerns by conducting attitude surveys and implementing people programs to take advantage of experience gained on the factory floor.

The design process is very critical to Harris. A lot of emphasis is given to the development and implementation of design guidelines and design analysis. Most of the design operation is computer aided. Some of the computer aided design data is even passed down to the vendor for board layout. One of the more useful practices applied by Harris was the exchange of engineering personnel between design and manufacturing.

Even with a factory of the future being established, a trade-off analysis is performed prior to investment in automated equipment. Often it has proven to be more cost effective to procure semi-automated equipment due to the process or the quantity of product for that work center. The utilization of space and equipment is well planned and beneficial to the total operation.

Most of the manufacturing problems identified by Harris GSSD have been discussed previously with other companies. As more surveys and discussions are conducted, all of the problems identified in this report and those identified in previous BMP reports will be reviewed and data will be collected to document the magnitude of the problem. Resolution of these problems may come from another company's efforts (best practice) or from research by a government activity such as the Electronics Manufacturing Productivity Facility in China Lake, California. By forming a collective government/industry position with documentation on issues and problems identified, and establishing a data base of the best practices used in industry, the chances of resolution are increased significantly.